



**US Army Corps
of Engineers®**

APPENDIX A5: STRUCTURAL ENGINEERING

WACCAMAW RIVER,

HORRY COUNTY, SOUTH CAROLINA

**FLOOD RISK MANAGEMENT STUDY INTEGRATED
FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT**

MAY 2026

MAIN REPORT SUMMARY

The Integrated Feasibility Report and Environmental Assessment (FR/EA), that this appendix addresses, details a collaborative study by the U.S. Army Corps of Engineers (USACE) and Horry County, South Carolina. It is aimed at reducing existing and future flood risks to communities and transportation infrastructure within the Waccamaw River Basin, with a focus on Horry County. The study identifies four key flood impact areas: Longs & Red Bluff, Conway, Bucksport, and Socastee.

The flood impacts in each of these areas were independent of each other, so solutions could be evaluated self-reliantly, making any proposed alternative plans separable. The study considered a range of structural, non-structural, and nature-based solutions while incorporating public feedback gathered during meetings. An environmental analysis was completed, and a Finding of No Significant Impact is included within the main report. The document completed a public review and comment period while also undergoing internal agency reviews and adapted to those concerns and suggestions. In addition to historical flooding, the report acknowledges the flooding event caused by Hurricane Debby in August 2024 during this study, and its impact was assessed to further inform the study's conclusions.

The Recommended Plan, based on an evaluation of alternatives, includes two separable elements that are incrementally justified: Relief Bridges (cross drains) in the Conway flood impact area and Barrier Removal in the Socastee flood impact area. The Recommended Plan is classified as the National Economic Development Plan and is also the plan that maximizes net comprehensive benefits. No alternatives were justified for Federal investment for the Longs & Red Bluff and Bucksport flood impact areas. This Appendix provides detailed Structural Engineering information to support these recommendations.

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A INTRODUCTION

After completion of and in conjunction with H&H analysis, the structural engineering scope of this feasibility study was determined to evaluate various flood wall barriers, the installation of relief bridges or culverts on existing roadways, and the installation of a storm surge gate. The types of barriers considered for this study consisted of Earthen Berms, I-Walls, and T-Walls; each barrier type has its own requirements, limitations, and footprint requirements. In addition, the relief bridges and culverts were evaluated based on the amount of additional flow needed. The report will discuss in more detail the use of the different flood wall barriers, and relief bridges or culverts.

The study was broken up into four main flood impact areas in Horry County. Below is the summary of structural requirements for each flood impact area. For more details and assumptions of the structural requirements for the flood impact areas, please refer to remainder of this appendix.

A.1 BUCKSPORT

In the Bucksport flood impact area, the study considered and evaluated the installation of a storm surge gate that would be installed across Cowford Swamp on the south side of the bridge along Old Pee Dee Road. The gate consisted of multiple sluice gates with a total width of ~800 feet, and ranging from 4-14 feet tall, with pile supported concrete T-Walls on the sides tying into higher ground, making a total length of ~0.6 miles. The gate would be open to allow normal flow of the creek and would be closed only for major storm events. This measure resulted in a BCR less than 1.0 and was ultimately screened out during the study.

A.2 CONWAY

In the Conway flood impact area, the study considered and evaluated the installation of relief bridges and/or culverts along HWYs 501, 501 Business, and 905. Conceptual size and locations of the relief bridges and culverts were determined to assist with modeling efforts, as well as 35% design development.

A.3 SOCASTEE

In the Socastee flood impact area, the study considered and evaluated the installation of a flood barrier along both banks of the Socastee Creek. Due to known soil conditions in the vicinity, an I-Wall was proposed for this structure. The I-Wall consisted of a reinforced concrete wall supported by steel sheet piles. The wall on the Right Bank was ~2.3 miles and the height ranged 5-9 feet above existing grade. The wall on the Left Bank was ~3 miles and the height ranged 5-9 feet above existing grade. This measure resulted in a BCR of less than 1.0 and was ultimately screened out during the study.

A.4 LONGS AND RED BLUFF

In the Longs flood impact area, the study considered and evaluated the installation of a floodwall along Buck Creek adjacent to the Aberdeen community and continuing north to Rolling Ridge Drive. Due to the anticipated soil conditions and height requirements of the wall, an I-Wall was proposed for this structure. The I-Wall would consist of a reinforced concrete wall supported by steel sheet piles and was 5-11 feet above existing grade with a length of ~3 miles. This measure resulted in a BCR less than 1.0 and was ultimately screened out during the study.

B ASSUMPTIONS AND LIMITATIONS

Due to the conceptual stage of this study, assumptions had to be made and there were limitations that existed. One major limitation was not having geotechnical reports in the footprint of the structures proposed. Therefore, soil conditions had to be assumed using known geotechnical data from projects in the vicinity of the proposed and evaluated structures. A geotechnical investigation was performed late in the project where the relief bridges or culverts were proposed. Also, the heights above existing grade were estimated using the best data obtained at the time.

However, given this is at a conceptual stage, conservative assumptions were made for the purposes of this report. These assumptions and limitations can be optimized during the Preconstruction Engineering and Design (PED) Phase.

B.1 EARTHEN BERM

Earthen Berms were ruled out as a viable option primarily due to their large footprint requirement (i.e. 10 ft wide top, 3 to 1 slope or 4 to 1 slope, vegetative free zone on each side, etc.). The locations where flood barriers were considered were in residential areas where the construction of the earthen berm would require acquisition of the residences the study is trying to protect. There may be opportunities to use earthen berms where the flood barrier crosses the golf course in Aberdeen, located in the Longs and Red Bluff flood impact area, in conjunction with the I-Walls proposed. However, due to the conceptual nature of where this project currently is, the team decided to use I-Walls and optimize the flood barrier if a flood barrier was selected as part of the TSP. Since the I-Wall has not been selected as part of the TSP due to the very low BCR that was calculated, further evaluation of earthen berms will not be considered as this study progresses. For berm footprint dimension, refer to the table below for Total Width requirements for earthen berms.

Table B-1: Earthen Berm Footprint Dimensions

Berm Height (ft) Above Existing Grade	10 ft Top Width		8 ft Top Width	
	3H : 1V	4H : 1V	3H : 1V	4H : 1V
	Total Width (ft)	Total Width (ft)	Total Width (ft)	Total Width (ft)
1	46	48	44	46
2	52	56	50	54
3	58	64	56	62
4	64	72	62	70
5	70	80	68	78
6	76	88	74	86
7	82	96	80	94
8	88	104	86	102
9	94	112	92	110
10	100	120	98	118
11	106	128	104	126
12	112	136	110	134
13	118	144	116	142
14	124	152	122	150

* Total Widths include a Vegetation Free Zone (VFZ) of 15 ft on each side of the berm

B.2 I-WALL

For the purposes of this study, I-Walls were considered for the floodwalls in the Longs and Red Bluff, and Socastee study areas. Working closely with the geotechnical engineer, the team was able to gather geotechnical reports from various projects within the vicinity of the proposed flood walls and determined that an I-Wall constructed with a reinforced concrete wall supported on steel sheet piles was adequate for the required heights. The I-Wall would have a concrete pad installed on the dry side for scour protection in the event the wall was overtopped during a major storm event. However, after the benefits were calculated and compared to the cost of construction of the I-Wall, the I-Wall had a BCR of less than 1.0. Therefore, the I-Wall was screened from further consideration.

B.3 T-WALL

For the purposes of this study, T-Walls were explored early in the study but were screened out after close coordination with the geotechnical engineer. Due to known soil conditions in the area, the T-Wall was considered to be more robust than what is needed for the study areas. In addition, the flood wall locations for this study are more inland and not coastal, so the wave loading is much smaller. Also, the seismic loading in Horry County is very small. Therefore, the major loading condition for the flood barrier is the flood loading.

B.4 RELIEF BRIDGES AND CULVERTS

Relief bridges and culverts were considered and evaluated along HWY's 501, 501 Business, and 905. H&H modeling was performed to determine the size needed to allow additional flow of flood waters under the roadways, that resulted in:

Highway 501 – 2 parallel 8'W x 7'H Precast Reinforced Concrete Box Culverts

Highway 501 Business – 2 parallel 8'W x 7'H Precast Reinforced Concrete Box Culverts

Highway 905 – 3 parallel 6'W x 3'H Precast Reinforced Concrete Box Culverts

The vertical dimension was restricted by the existing grade of the road. Also, standard size box culverts were obtained with concrete precast plants. The positioning of the relief bridges and culverts would comply with SCDOT requirements to ensure they do not interfere with existing bridges along the roadways. Refer to Appendix A3: Civil Engineering for additional information about the precast box culverts. Due to Federal Highway Administration (FHWA) requirements, if multiple adjacent culverts cumulatively span more than 20 feet, then the culverts will need to be load rated. Currently the cumulative spans in the proposed locations do not exceed 20 feet. In addition, existing utilities may need to be relocated or renovated to allow for installation of the relief bridges and culverts.



Figure B-1: Box Culvert with Wingwalls example

C LOADS

All flood barriers will be designed to meet the requirements and guidance of the EM 1110-2-2502, and all relief bridges will comply with SCDOT and AASHTO criteria. More detailed information on the loads for the associated structures and load combinations are listed below.

C.1 FLOOD BARRIERS

The load cases considered for this study were in accordance with Inland Flood Wall requirements in EM 1110-2-2502. To date, analysis has not been completed, but engineering judgement and close coordination with the geotechnical engineer were used at this stage. More detailed analysis and site-specific geotechnical investigations would need to be completed during PED Phase.

Case I1: Design Flood Loading

Case I2: Water to Top of Wall

Case I3: Earthquake Loading

Case I4: Construction Short-Duration Loading

C.2 RELIEF BRIDGES

All bridges will be designed to SCDOT requirements, as well as culverts that will be placed under the roads. All culverts will be rated to support vehicular traffic, including the HL-93 truck loading, and if the cumulative span of adjacent culverts is more than 20 feet then the culverts will be load rated. However, the cumulative

spans in the proposed locations did not exceed 20 feet. As the study progresses and optimization occurs, additional information and detailing would be completed. Working closely with H&H and the rest of the engineering team, the sizes of the culverts and bridges would be optimized, and some preliminary detailing would be done to prevent erosion. This could be accomplished using rip rap or large stone to prevent scour or erosion. In addition, working closely with Geotech would help determine the foundation system needed and if site improvements would be required.

D GATES

A storm surge gate system that would tie into adjacent higher ground was considered and evaluated in the Bucksport study area. The gate would primarily be open to allow for normal flow of water and boat recreation that occurs. However, during major storm events the gate would be closed to hold back the storm surge. It was anticipated that the gate structure would be pile supported since it would be constructed in the creeks waterway and would need a seepage wall to prevent water seeping underneath the wall during times of high water levels. The walls that would tie the structure into high ground still needed to be determined, but due to current analysis, these walls were expected to be I-Walls, which were discussed earlier in this Appendix.

However, after modeling was completed, and the cost of construction was compared to the benefits, the storm surge gates produced a BCR of less than 1.0. Therefore, they were screened from further consideration.

E FUTURE DETAILING AND RESILIENCY

For this study, the only structural measure that was not screened out was the relief bridges or culverts. These are common drainage structures primarily constructed of reinforced concrete. One way to ensure resiliency would be to provide thicker slabs or walls to all for additional wearing surface of the culverts. Also, providing rip rap or erosion protection around the inlet and outfalls would prevent or slow down erosion due to the flow of water.

F REFERENCES

- EM 1110-2-2502 Retaining and Flood Walls
- EM 1110-2-2906 Design of Pile Foundations
- EM 1110-2-2104 Strength Design for Reinforced Concrete Hydraulic Structures
- ER 1110-2-1806 Earthquake Design and Evaluation for Civil Works Projects

American Association of State Highway and Transportation Officials (AASHTO)

SCDOT - Bridge Inspection Guidance Document – Technical Note No. 1 – May 2022